ed, after that another, and a third near the *Pomum Adami*; by theſe the Bullet was diſcover'd, and cut out in *Auguſt* 1672.

IX. *An Account of Books*; viz. I. *Prælectiones Chymicæ* Oxoniæ *habitæ a* Johanne Freind, *M. D. Ædis Chriſti Alumno.*

THO' the Art of Chymiſtry is at preſent much improved, and abounds with many excellent and uſeful Experiments; yet it muſt be acknowledg'd, that hitherto there has been made but a very little Progreſs in the Philoſophy of it; and that Men are ſtill to ſeek for the Reaſons of the many ſtrange Phænomena it produces. The Chymiſts generally making uſe of ſuch Principles as have no foundation in Nature, it is no wonder if their Philoſophy is inconſiſtent with it ſelf, and is neither to be explain'd or underſtood. On this Account the Learned Author of this Excellent Treatiſe, without conſidering the Principles and Errors of former Chymiſts, endeavours here to give a clear and eaſie Account of the chief Operations of Chymiſtry from the true Principles of Natural Philoſophy, and chiefly that of *Attraction*; which, he ſays, is no Figment or Hypotheſis, but deduced from many plain Experiments, and grounded on the Laws of Nature and that Habitude that is found among Bodies, but particularly from the Obſervations that are to be made in Chymiſtry it ſelf. This Principle of Attraction, with ſeveral other Lemma's that are borrowed from Geometry and Mechanicks, he explains and lays down as Axioms, which are to be underſtood, before any Progreſs can be made in the Science of Nature.

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Nature. And becauſe Chymiſtry is an Art of joyning Bodies that are ſeparated, or ſeparating ſuch as are joyned, he divides the Operations of Chymiſtry into two ſorts; *viz.* ſuch as diſunite the Parts of Bodies from one another, and ſuch as compound or mix them together. The Chymiſts not agreeing what are to be put in the ſecond Claſs and what in the firſt, he follows a new Order, and among the firſt Claſs he reckons *Calcination*, *Sublimation* and *Diſtillation*; in the ſecond are ranked *Fermentation*, *Digeſtion*, *Extraction*, *Precipitation* and *Cryſtallization*.

His deſign in this Treatiſe is to explain firſt, The Method of each Operation according to this Order, and the Mechanical force by which it is produced. Secondly, The different ways by which it commonly is, or may be performed: And Thirdly, He gives us many particular Experiments, which he explains and reduces to the General Theory laid down at firſt. Accordingly we have here the reaſon of the Coheſion of Bodies, which he draws from the Principle of Attraction, and the quantity of Contact; the Cauſes of Fluidity and Liquation; the reaſon why ſome Bodies, as Wax and Metals, being melted in the Fire, and afterwards cooled, do return to their firſt Form, whereas others by Fire acquire a new one: How it comes about, that the abſolute weight of Bodies is generally after Calcination encreas'd, and the Specifick Gravity diminiſh'd. We have alſo the reaſon, why Fluids riſe in an Alembick; and he ſhows that if a Globule of Water be ſo rarified, as to have its Diameter made only ten times greater, it will become lighter than the Air, and conſequently muſt riſe up in it: But if the Diameter be encreaſed in the proportion of 12 to 1, the Bubble of Water becomes more than twice as light as our common Air, and muſt therefore riſe ſo much the faſter. Beſides this, the Air itſelf being rarified muſt neceſſarily riſe up, and the force of its motion carry ry with it what Bodies it meets with in its way; which will more eaſily aſcend according as their Surfaces are greater in proportion to their weight. And our Author tells us, that if the Specifick weight of Bodies, the force that impels them, and the meaſure of their Surfaces be rightly conſider d, it will be no hard matter to give an account of Volatility and Fixedneſs, and all the appearances of Diſtillation and Sublimation; in which laſt only ſolid Bodies are raiſed by the force of Fire.

In his Lecture on Fermentation, he deduces the cauſe of Ebullition and Effervescence from the attractive force of the Particles of Matter, and particularly thoſe of Salts; which he ſays are very ſimple and ſmall Bodies, and in proportion to their bulk very ſolid, and muſt of conſequence be endowed with a very ſtrong attractive Power. Upon which account, and that of the ſmallneſs of their force of Coheſion, he ſhows the reaſon why they are ſo eaſily diſſolved into Water, and not in Spirit of Wine; as alſo why Water can only diſſolve a certain proportion of theſe Salts, ſo that whatever quantity greater than this is immerſed in Water, remains undiſſolved.

The Solution of all other Bodies is to be deduced from the ſame Principles; but to underſtand them rightly, it is neceſſary to eſtimate the wideneſs of the Pores of theſe Bodies, the force by which the Parts cohere together, and the efficacy or force of motion in the Parts of the Menſtruum; which laſt ariſes from the difference of attractions of the Particles of the Menſtruum to one another, and to the Parts of the Body, and from their elaſticity. And upon theſe Grounds he explains the various Phœnomena of Diſſolutions; particularly of that hitherto unaccountable one of *Aqua Regia* diſſolving *Gold*, but not *Silver*, whereas *Aqua Fortis*, of which the *Aqua Regia* is made, diſſolves *Silver* but not *Gold*; which he illuſtrates and reduces to a plain Calculation.

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In the Lectures on Digeſtion and Extraction,he ſhows that there is a Tenacity in all Fluids,by which their Parts do in ſome meaſure cohere together, and hinders their Effects from being the ſame as in a perfect Fluid. He gives us the method of eſtimating this Tenacity, and of finding out the proportion it may have to the weight of other Bodies; and from thence he explains how ſmall Particles of Matter, that are either ſpecifically lighter or heavier than the Fluid, may be ſuſtained in it, which he explains by a Calculation; and ſhows, that if the Gravity of the Body be to the Tenacity of the Fluid as P to 1, if the Body be divided into Parts, whoſe Diameters are to the Diameter of the whole as 1 to P, then theſe Bodies may be ſuſtained in the Fluid, tho' ſpecifically lighter than themſelves.

He obſerves, that Tinctures made by Digeſtion are uſually very ſtrong, and ſaturated with the Body whoſe Tincture is extracted; but if the Tincture be diſtilled in an Alembick, the Menſtruum generally riſes with its former colour and clearneſs, leaving the Body behind it: The reaſon of which he explains.

He conſiders the ſeveral Preparations of Opium, and condemns ſuch as are made by the fumes of Sulphur, or by acid Liquors; in which either the vertue of the Opium is loſt, by the evaporation of its Volatile Particles, or deſtroyed by acid Salts, whoſe qualities are directly oppoſite to that of Opium; the one coagulating or making the Blood viſcid, whereas the other attenuates it, and renders it fluid: But he approves of ſuch Preparations of Opium as are made with hot and aromatick Medicines, which heighten its Vertue; and ſeems to prefer Dr. *Sydenham*'s Preparation with Canary Wine to all others.

Precipitation, he ſays, may be made by infuſing a Liquor, that is ſpecifically lighter or heavier than the Menſtruum: For by the firſt the Æquilibrum that was

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between the Gravity of the Particles ſwimming in the Menſtruum, and the Tenacity of the Fluids, is deſtroyed, on which account they muſt ſink. By the ſecond, the Particles will be carried down to the bottom by the force of a heavier Fluid. He ſhows likewiſe, how Precipitation may be cauſed by infuſion of Saline Menſtruums, whoſe Salts attracting the Particles that ſwim in the Fluid, and cohering with them, they will form ſuch Bodies, whoſe Gravity will over-power the Tenacity of the Fluid, and deſcend. From which Principle he deduces the reaſon of all Chymical Coagulations.

In Cryſtallization of Salts, he obſerves, that a great part of the Fluid, in which they are diſſolved, is evaporated: On which account, their Particles coming nearer to one another, their attractive force is encreaſed, and they will come and unite together; and becauſe the Figures of the minute Particles of each Salt are always uniformly the ſame, and their attractions being ſtronger on one ſide than another, they will always cohere to one another in ſuch ſides as have the greateſt attractive force. On which account they muſt neceſſarily form Bodies of certain determin'd Figures, which in the ſame ſort of Particles are always the ſame.

II. *An Account of Animal Secretion, the quantity of of Blood in the Human Body, and Muſcular Motion.* *By* James Keill, M. D.

THE Author of theſe Diſcourſes prefixes a Preface, wherein he ſhows the neceſſity of a right Knowledge of the Principles of true Philoſophy, and of the Animal Oeconomy in the Practice of Phyſick; where our Skill in curing Diſeaſes, whoſe Hiſtories are known, is always proportional to our Knowledge of the Animal Oeconomy, which of it ſelf is a conſiderable part of Natural Philoſophy. He does indeed blame the too common Method of Philoſophizing on Principles not drawn from Nature, but ſuch as are the uncertain fictions of the Brain, whoſe real exiſtence can never be deduced from Experiments. This ſort of Philoſophy, he ſays, is very prejudicial to Phyſick: Men being generally fond of their own Productions, have not ſtuck to mould new Diſeaſes to anſwer their Hypotheſis; ſo that moſt of the late Hiſtories of Diſeaſes are only Philoſophical Romances; but notwithſtanding this, Natural Philoſophy, and the Hiſtory of Diſeaſes muſt go Hand in Hand in improving the Art of Curing: And he affirms, that there is no Man that practiſes, but who does it on ſome Knowledge of the Animal Oeconomy, or ſome Notions of his own, which are more or leſs clear, according to his Skill in Natural Philoſophy. He proves likewiſe from *Hypocrates* and *Galen*, that the Principle of Attraction of the ſmall Particles of Matter to one another, was known to the Ancients; the Philoſophy of *Hypocrates* being built on a certain propenſion which ſome things have to one another, whereby they attract, retain, and alter each other.

In the firſt Diſcourſe, he proves by Obſervation, that both the red and ſerous parts of the Blood are endowed with an attractive Power; and as in the Blood the Particles attract one another, and cohere together, ſo likewiſe do the Particles of different Fluids, that are ſeparated from it by Secretion. He ſays, it is evident that ſome of the Fluids, that are ſecern'd from the Blood by the Glands, are really compos'd by the coheſion of ſeveral ſorts of Particles; for in Milk there are 3 or 4 ſeveral ſorts of Subſtances. Urine has the ſame appearances, and contains perhaps more Principles, and there is no doubt but that Tears, Spittle, and Sweat are all compounded Liquors. Now if the Particles which attract one another, are ſtill more powerfully attracted by the Fluid in which they ſwim than by one another, they can never of themſelves ſeparate from the Fluid; which is the caſe of Salts diſſolved in a large proportion of Water, and of Urine when it neither breaks nor ſettles: But if the Particles ſwimming in the Fluid are more ſtrongly attracted by one another than by the Fluid, they muſt neceſſarily ſeparate from it, and go into parts which will either ſink, ſwim, or aſcend in the Fluid, according to their ſpecifick Gravity. This power of Attraction, he ſays, is univerſally difuſed throughout all Matter, and the real exiſtence of it, he ſays, can be denyed by none that will duly conſider the Experiments and Reaſons given by Sir *Iſ. N.* in the Queſtions annexed to the Latin Edition of his Opticks; and it ſeems to be the only Principle from which there can be drawn a ſatisfactory Solution of the Phænomena produced by the *Minima Naturæ.* And becauſe the whole Animal Oeconomy depends upon it, he lays down in eleven Propoſitions ſo many of the Laws of that univerſal Attraction, with their Demonſtrations, as are requiſite for his preſent purpoſe; and then proceeds to ſhow how the Corpuſcles that compoſe the

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Secretions are formed in the Blood before they arrive at their ſecerning Glands: But becauſe the Particles of the Blood returning by the Veins and attracting one another, are formed into Globules too big for any Secretion, he ſhows how theſe Globules are broken and divided in the Lungs by the force of Reſpiration: And from Experiments, and the Doctrine of Staticks, he calculates the preſſure of the Air upon the Lungs to be equal to the weight of 100 Pound; and becauſe the difference between the greateſt and leaſt Gravity of the Air is $\frac{1}{10}$ of the greateſt, he from thence ſhows how Aſtmatick People are very ſenſible of this difference, eſpecially when they breathe thicker; for if they perform their Expiration in half the uſual time, it will make this difference equal to 40 Pound weight, which is almoſt equal to half the Preſſure of the Air in ordinary Breathing.

He ſhows, in the next place, how from the great Velocity of the Blood, the friction on the Coats of the Veſſels, the Impetus of the Particles on one another, and their Elaſticity, there muſt needs ariſe near the Heart a ſtrong inteſtine Motion in the Blood, on which depends its heat; and by conſequence near the Heart, where the Motion is greateſt, the union of the Particles will be in a great meaſure hinder'd; and therefore the Particles that unite firſt, are ſuch as have the ſtrongeſt attractive force, and ſuch as have the leaſt, are the laſt in uniting. The Particles endowed with the ſtrongeſt attractive Powers, are, by his 2d Prop. the moſt Solid and Spherical Corpuſcles; and their quantity of Contact being the leaſt, the Secretion they compoſe muſt be the moſt Fluid: Such is the Liquor in the *Pericardium*.

Upon the ſame Principle, he gives the Reaſon of the ſituation of the Kidneys ſo near the Heart, that the Salts that are in Urine, being ſtrongly attractive, and uniting cloſely

cloſely with the watery Fluid, may quickly be drawn of from the Blood. The Corpuſcles which are ſloweſt in uniting, muſt be ſuch as have the weakeſt attractive Force; which by his 2d Prop. are ſuch as have the leaſt Solidity, but their Surfaces moſt extended; and therefore Corpuſcles, which have plain Surfaces, are longer in uniting than the Spherical ones; but when united, they cohere moſt ſtrongly by his 9th Prop. and compoſe the moſt viſcid Fluids: Such are the Mucilages of the Joints, which are ſeparated at the greateſt diſtance from the Heart.

Tho' the Secretion of the Gall by the Liver, and of the Seed by the Teſticles, may ſeem to be conſiderable Objections againſt this Doctrine, yet there is really nothing that more illuſtrates and confirms it than the manner of forming theſe Secretions. Had the Blood been immediately convey'd by the Celiack Artery to the Liver, it is evident, that on the account of the nearneſs to the Heart, and the Inteſtine motion of the Blood, that ſo viſcid a Secretion, as the Gall is, could never have had time to have been formed in the Blood, and ſecerned in that place; and therefore here Nature is forced to change her conſtant Courſe of ſending Blood to all Parts by the Arteries, and forms a Vein, by which the Blood is derived to the Liver from the Branches of the Meſenterick and Celiack Arteries, after it has paſſed through all the Inteſtines, Stomach, Spleen, Caul, and Pancreas. By this extraordinary contrivance, the Blood is brought a great way about, before it arrives at the Liver; and its Velocity being extreamly diminiſh'd, the Corpuſcules will have time to unite and form the Gall: And here our Author calculates the Velocity of the Blood that comes into the Liver, and proves, that what comes by the Meſenterick Artery into the Porta, moves 177 times ſlower in the Branches of the

Porta than in the Trunk of the Meſenterick Artery, and the Blood which comes from the Spleen to the Liver, moves 200 times ſlower in the Spleen than in the beginning of the Splenick Artery; and from thence deduces the long ſought for Uſes of the Spleen and Porta: So productive is one ſimple truth of many others.

There is another contrivance for diminiſhing the Velocity of the Blood in the Teſticles, which the Author explains, and ſhows that the Blood muſt be 150 times longer in paſſing to the Teſticles the way it does, than if it had gone according to the common Courſe of Nature. After this the Author proceeds to explain the ways of forming other Secretions, as the . . . of the Ear, the Lymph, and Animal Spirits. He ſhows likewiſe, how from the Doctrine of Attraction the Operation of Medicines, which alter the quantity of Secretions, may be explained; for Medicines that encreaſe the quantity of any Secretion, operate by uniting to and augmenting the Attractive force of the Particles, that compoſe the Humours to be ſecerned, which may be more effectually done by the Particles of one ſort of Medicine than thoſe of another, and therefore different Humours will require different Purgatives to carry them off through the Glands of the Inteſtines; which Conſideration will re-eſtabliſh the Doctrine of Specifick Purges, which was confirm'd to the Antients by Experience and Obſervation, but rejected by the Moderns thro' a falſe Philoſophy.

He proceeds after this, to ſhow how neceſſary the Doctrine of Secretion founded on Attraction is, for the underſtanding of the Nature of Diſeaſes; and gives us an example in a Diabetes. He likewiſe explains from it ſome of the Symptoms of Rheumatiſms, Gout, and Stone; as alſo the Operations of Medicines in the Humane Body, eſpecially the attenuaters and thickners of the Blood, but more particularly the Power of Mercury in the Cure of a Gonorrhea or Pox; which are all ſo eaſily explained by the attractive power of Matter, that now no body can doubt of the truth of a Principle ſo ſimple, which yet like a Maſter Key, opens the Works of very different contrivances, and diſcloſes an Uniformity in all the Operations of Nature: So that every one may ſee and read the ſame thought and hand in the contrivance and framing of every part of the Univerſe.

Having given us the Method by which the ſeveral ſorts of Fluids are formed in the Blood before they are ſeparated from it, he then explains the way by which theſe Liquors are ſecerned by the Glands, and he proves, that the Orifices of all the Glands muſt be circular, and that they can only differ in magnitude; and therefore all the Particles that arrive at the Orifice of any Gland, and are of a leſs Diameter than that of the Orifice, will enter the Gland: So that if there were no other contrivance in it, the Fluid which contains the biggeſt Particles, will likewiſe conſiſt of all the Particles of the other Secretions; but this inconveniency is obviated, by imagining ſeveral Tubes to ariſe from the ſide of the Canal or Duct of the Gland, whoſe Orifices are of ſuch Demenſions, that they will admit only Particles, which are ſmaller than thoſe that are to be ſecerned by the Gland; and a great many of them ariſing from the ſides of the Canal, throughout its whole Circumvolution, will carry back to the Blood the Particles which are of a leſs Diameter than thoſe have, which are to be diſcerned; ſo that there will at leaſt remain in the Gland only theſe Particles, with ſuch a proportion of the watry Fluid, as is neceſſary for the proper fluidity of the Liquor to be ſecerned.

In the Diſcourſe on the quantity of Blood, he proves that the common Opinion that there are but 15 or 20

Pounds of Blood in the Body, is founded on no good grounds; they ſuppoſing that when an Animal bleeds to death, that all the Blood in the Body runs out of the Wound, which the Author ſhews to be falſe; for the larger the Veſſel that is wounded is, the ſooner muſt the Animal dye; and if the *Aorta* it ſelf were cut aſunder, there would be a leſs effuſion of Blood from it, than from a ſmall Artery: And from this he explains the true reaſon of fainting on any ſudden or violent Evacuation, as in Bleeding in the Arm, Copping in an Aſcites, *&c.*

By Blood he underſtands not only the Fluids in the Veins and Arteries, but all the circulating Liquors in the Body, they being all parts of the Blood, and ſeparated from it by the force of the Heart, and many of them by the ſame force returning again: And in order to eſtimate its quantity, he ſuppoſes that the whole Body is nothing but Tubes or Veſſels full of Blood or Liquors derived from it; and then according to the various proportions of the thickneſs of the Coats of the Veſſels to their Cavities, he calculates what the quantity of Blood muſt be; and finds, that if the Body weigh 160 Pounds, it muſt at leaſt contain 100 Pound weight of Blood.

He next conſiders the Velocity of the Blood, and determines it. And firſt he determines the ſwiftneſs by which it is thrown into the *Aorta*, which he finds to be ſuch as will make it move 52 foot in a Minute; and becauſe the ſum of the Section in the Branch of an Artery is always greater than that of the Trunk, the Velocity of the Blood muſt conſtantly decreaſe as the Artery branches. And according to the various proportions which the Branches bear to the Trunk, he calculates the Velocity at the extremities or evaneſcent Arteries, and finds that if the Trunk did always bear the proportion to the Branches of 41616 to 43506, the Blood

Blood would move at leaſt four times ſlower in the extremities than in the great Artery. But if the proportion of the Trunk to the Branches were always 41616 to 52126, which is frequently obſerved, the greateſt Velocity of the Blood will be to the leaſt as 10000 is to 1.

In his Diſcourſe on Muſcular Motion, he proves that the Veſicles of each Fibre in the action of a Muſcle are inflated by the rarefaction of the Blood and Spirits within their Cavities; and explains the cauſe of this Inflation and Rarefaction from the Principles of Attraction: And then he ſhows, by increaſing the number of Veſicles, and diminiſhing their bigneſs, the ſwelling of the Muſcle may be made ſo little, as to be unperceptible, and the expence of Spirits very much leſſened, and yet there will be the ſame degree of Contraction in the Muſcle.

He then proceeds to determine the force of the Elaſtick Fluid, and its Proportion to the weight that is to be raiſed, according to the various degrees of Inflation: His Demonſtrations here are founded on the ſame Principles with thoſe of Mr. *John Bernoulli*, but more eaſy, and ſuited to the Capacity of thoſe that are not verſed in the deep parts of Geometry.

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